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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : C07K 7/26, A61K 37/02 | A1

(11) International Publication Number: WO 91/09056

(43) International Publication Date: 27 June 1991 (27.06.91)

(21) International Application Number: PCT/US90/07074

(22) International Filing Date: 4 December 1990 (04.12.90)

(30) Priority data:
447,876 8 December 1989 (08.12.89) US

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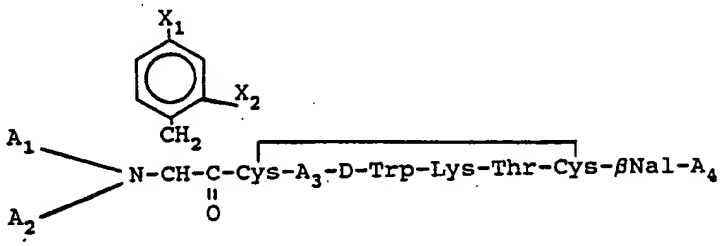
(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), HU, IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: OCTAPEPTIDE ANALOGS OF SOMATOSTATIN HAVING THREONINE AT THE SIXTH POSITION



(I)

(57) Abstract

A compound of formula (I), wherein each A_1 and A_2, independently, is H C_{1-12} alkyl, C_{7-10} phenylalkyl, R_1CO (where R_1 is C_{1-20} alkyl, C_{3-20} alkenyl, C_{3-20} alkenyl, phenyl, naphthyl, or C_{7-10} phenylalkyl), or R_2OCO (where R is C_{1-10} alkyl or C_{7-10} phenylalkyl), provided that when one of A_1 or A_2 is R_1CO or R_2OCO, the other must be H; each X_1 and X_2, indepently, is H, F, Cl, Br, OH, CH_3, or CF_3, provided that at least one of X_1 and X_2 must be H; A_3 is Phe or Tyr; and A_4 is OH, NH_2, or NH-R_3 (wherein R_3 is a saturated aliphatic C_{1-8} alkyl): or a pharmaceutically acceptable salt thereof; a therapeutic composition comprising such compound; and a method of using such compound.

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OCTAPEPTIDE ANALOGS OF SOMATOSTATIN HAVING THREONINE AT THE SIXTH POSITION

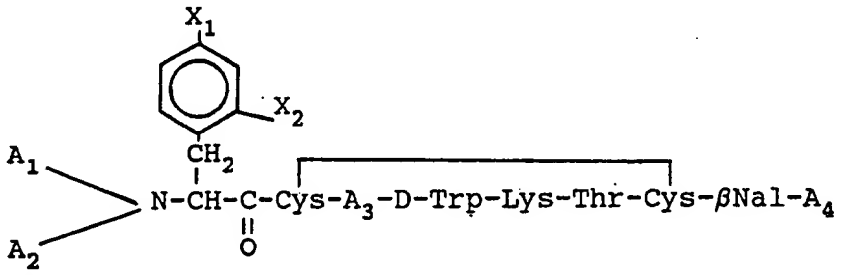
Background of the Invention

This invention relates to therapeutic peptides.

A number of somatostatin analogs exhibiting growth hormone-release-inhibiting activity have been described in the literature, including analogs containing fewer than the naturally-occurring fourteen amino acids. For example, Coy et al., U.S. Patent No. 4,485,101, hereby incorporated by reference, describes dodecapeptides having an amino-terminal acetyl group, a carboxy-terminal amino group, D-Trp at position 6, and p-Cl-Phe at position 4. (The name of each amino acid is herein designated by its standard three-letter abbreviation; the stereoisomeric designation of each amino acid is L unless otherwise specified.)

Summary of the Invention

In general, the invention features a compound of the formula:



wherein

each A_1 and A_2, independently, is H C_{1-12} alkyl, C_{7-10} phenylalkyl, R_1CO (where R_1 is C_{1-20} alkyl, C_{3-20} alkenyl, C_{3-20} alkenyl, phenyl, naphthyl, or C_{7-10} phenylalkyl), or R_2OCO (where R is C_{1-10} alkyl or C_{7-10} phenylalkyl), provided that when one of A_1 or A_2 is R_1CO or R_2OCO, the other must be H;

each X_1 and X_2, independently, is H, F, Cl, Br, OH, CH_3, or CF_3, provided that at least one of X_1 and X_2 must by H;

A_3 is Phe or Tyr; and

A_4 is OH, NH_2, or NH-R_3 (wherein R_3 is a saturated aliphatic C_{1-8} alkyl):

or a pharmaceutically acceptable salt thereof. The naturally-occurring amino acids are indicated by their generally-accepted three-letter symbols; unless the D-stereoisomer of an amino acid (other than βNal) is specified, the L-form is assumed. "βNal" denotes D- or L-β-naphthylalanine, unless the D- or L- stereoisomer is specified.

In preferred embodiments, each A_1 and A_2, independently, is H or a saturated aliphatic C_{1-3} alkyl; each X_1 and X_2, independently, is H, F, Cl, or OH, provided that at least one of X_1 and X_2 must be H; and R_3 is saturated aliphatic C_{1-3} alkyl; more preferably, the compound has the formula:

D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-βNal-NH_2

or

D-Phe-Cys-Tyr-D-Trp-Lys-Thr-Cys-βNal-NH_2

In another aspect, the invention features compounds of the formula:

D-βNal-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH_2

and

D-βNal-Cys-Tyr-D-Trp-Lys-Thr-Cys-Thr-NH_2

or a pharmaceutically acceptable salt thereof.

Also featured is a combination of one of the above compounds and a pharmaceutically acceptable carrier

substance in a therapeutic composition capable of inhibiting the release of growth hormone ("GH"), epidermal growth factor, insulin, glucagon, pancreatic exocrine secretions, or substance P, and preferably of GH.

In preferred embodiments, the composition is in the form of a pill, tablet, capsule, or liquid for oral administration; a cream, gel, lotion, spray or ointment for application to the skin of a patient; a liquid capable of being administered nasally as drops or spray; or a liquid capable of intravenous, subcutaneous, parenteral, or intraperitoneal administration. The therapeutic composition can also be in the form of an oil emulsion or dispersion in conjunction with a lipophilic salt such as a pamoic acid, or in the form of a biodegradable sustained-release formulation for subcutaneous or intramuscular administration. For maximum efficacy, zero-order release is desired. Zero-order release can be obtained using an implantable or external pump to administer the therapeutic composition.

The compounds of the invention exhibit a broad range of biological activities related to their antisecretory and antiproliferative properties. The compounds suppress the secretion of several endocrine hormones, including insulin, glucagon, and, in particular, growth hormone (GH). The compounds of the invention also suppress pancreatic and gastric exocrine secretions, and suppress or modulate the release of some neurotransmitters, including substance P and acetylcholine.

The somatostatin analogs can effect tumor cell multiplication by preventing the release of mitotic factors (such as insulin-like growth factor 1 (IGF-1), gastrin-releasing peptides, etc.), and may interfere with the intracellular transduction mechanism, as, for

example, in the case of epidermal growth factor (EGF)-induced cell proliferation.

The aromatic lipophilic N-terminal end can provide long-lasting in vivo activity.

Other features and advantages of the invention will be apparent from the following description of the preferred embodiments thereof, and from the claims.

Description of the Preferred Embodiments

Structure

The compounds of the invention, which are peptide analogs of somatostatin, have the general formula recited in the Summary of the Invention, above.

The compounds can be provided in the form of pharmaceutically acceptable salts or complexes. As used herein, the term "pharmaceutically acceptable salts or complexes" refers to salts or complexes that retain the desired biological activity of the parent compound and do not impart any undesired toxicological effects. Examples of such salts are (a) acid addition salts formed with inorganic acids (for example, hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid, and the like), and slats formed with organic acids such as acetic acid, oxalic acid, tartaric acid, succinic acid, malic acid, ascorbic acid, benzoic acid, tannic acid, pamoic acid, alginic acid, polyglutamic acid, naphthalenesulfonic acids, naphthalenedisulfonic acids, and polygalacturonic acid; (b) base addition salts formed with polyvalent metal cations such as zinc, calcium, bismuth, barium, magnesium, aluminum, copper, cobalt, nickel, cadmium, and the like, or with an organic cation formed from N,N-dibenzylethylene-diamine or ethylenediamine; or (c) combinations of (a) and (b): e.g., a zinc tannate salt or the like.

Synthesis

The synthesis of one octapeptide follows. Other compounds of the invention can be prepared by making appropriate modifications, within the ability of someone or ordinary skill in this field, or the following synthetic method.

The first step in the preparation of D-Phe-Cys-Phe-D-Trp-Lys-Val-Cys-βNal-NH_2 was the preparation of the intermediate tert-butyloxycarbonyl-D-Phe-S-methylbenzyl-Cys-Phe-D-Trp-N^{ϵ}-benzyloxycarbonyl-Lys-Thr-S-methylbenzyl-Cys-βNal-NH_2-benzyhydrylamine resin, as follows.

Methyl-benzyhydrylamine-polystyrene resin (Advanced Chem-Tech, Inc.) in the chloride ion form was placed in the reaction vessel of a Beckman 990B peptide synthesizer programmed to perform the following reaction cycle: (a) methylene chloride; (b) 33% trifluoroacetic acid in methylene chloride (2 times for 1 and 25 min each); (c) methylene chloride; (d) ethanol; (e) methylene chloride; (f) 10% triethylamine in chloroform.

The neutralized resin was stirred with Boc-βNal and diisopropylcarbodiimide (1.5 mmole each) in methylene chloride for 1 h and the resulting amino acid resin was then cycled through steps (a) to (f) in the above wash program. The following amino acids (1.5 mmole) were then coupled successively by the same procedure: Boc-S-methylbenzyl-Cys, Boc-Thr, Boc-N^{ϵ}-benzyloxycarbonyl-Lysine, Boc-D-trp, Boc-Phe, Boc-S-methylbenzol-Cys, Boc-D-Phe.

The resin was washed and dried and then mixed with anisole (4 ml) and anhydrous hydrogen fluoride (36 ml) at 0°C and stirred for 45 min. (one can also use thioanisole, trifluoroacetic acid, and trifluoromethane sulfonic acid at a ration of 1:90:9, for 6 h). Excess hydrogen fluoride was evaporated rapidly under a stream

of dry nitrogen and free peptide precipitated and washed with ether. The crude peptide was then dissolved in 800 ml or 90% acetic acid, to which was added I_2 in methanol until a permanent brown color was present. The solution was then stirred for 1 h before removing the solvent in vacuo. The resulting oil was dissolved in a minimum volume of 50% acetic acid and eluted on a column (2.5 X 100 mm) of Sephadex G-25. Fractions containing a major component by UV absorption and thin-layer chromatography were then pooled, evaporated to a small volume, and applied to a column (2.5 X 50 cm) or Vydac octadecylsilane (10-15 μM).

The column was eluted with a linear gradient of 10-50% acetonitrile in 0.1% trifluoroacetic acid in water. Fractions were examined by thin-layer chromatography and analytical high-performance liquid chromatography, pooled to give maximum purity, and, if desired, a different salt prepared, e.g., acetate or phosphate. Repeated lyophilization of the solution from water gave 120 mg of the product as white, fluffy powder.

The product was found to be homogeneous by high-performance liquid chromatography and thin-layer chromatography. Amino acid analysis of an acid hydrolysate confirmed the composition of the octapeptide.

Compounds of the invention having the formulas

D-Phe-Cys-Tyr-D-Trp-Lys-Thr-Cys-βNal-NH_2,

D-βNal-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH_2,

and

D-βNal-Cys-Tyr-D-Trp-Lys-Thr-Cys-Thr-NH_2

were made according to methods analogous to those described above.

Use

When administered to mammals, particularly humans (e.g. orally; topically; intravenously; parenterally in a sustained release, biodegradable form; nasally; or by suppository), the compounds can be effective to inhibit the secretion of various hormones and trophic factors. They may be used to suppress certain endocrine secretions, such as GH, insulin, glucagon and prolactin, the treatment of, for example, acromegaly; endocrine tumors such as carcinoids, vipomas, insulinomas, and glucagonomas; or diabetes and diabetes-related pathologies, including retinopathy, nephropathy, dawn syndrome and type 2 diabetes. The compounds may also be used to suppress exocrine secretions in the pancreas, stomach and intestines, for treatment of, for example, pancreatitis, fistulas, bleeding ulcers, and diarrhea associated with such diseases as AIDS of cholera. Disorders involving autocrine or paracrine secretions of trophic factors such as IGF-1 (as well as some endocrine factors) which may be treated by administration of these compounds include cancers of the breast, prostate, and lung (both small cell and non-small cell epidermoids) as well as hepatomas, neuroblastomas, colon and pancreatic adenocarcinomas (ductal type), chondrosarcomas, and melanomas, and also atherosclerosis associated with vascular grafts and restenosis following angioplasty.

The compounds of the invention also are useful to suppress the mediators of neurogenic inflammation (e.g., substance P or the tachykinins), and thus may be used in the treatment of such pathologies as the rheumatoid arthritis; psoriasis; topical inflammation such as is associated with sunburn, eczema, or other sources of itching; and allergies, including asthma. The compounds also can function as neuromodulators in the central nervous system, with useful applications in the treatment

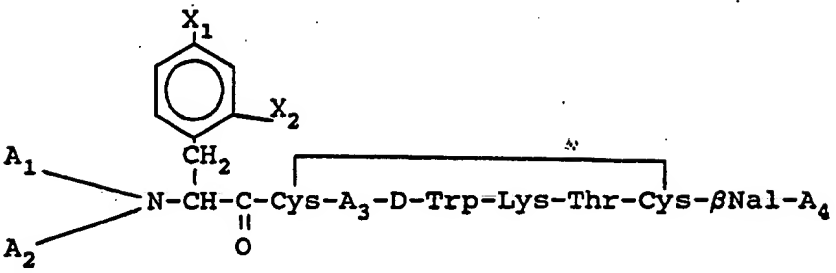
of Alzheimer's disease and other forms of dementia, pain (as a spinal analgesic), and headaches. Furthermore, in disorders involving the splanchnic blood flow, including cirrhosis, oesophageal varices, and certain cases of mushroom poisoning, the compounds of the invention can provide cytoprotection.

The compounds can be administered to a mammal, e.g., a human, in a dosage of 0.01 to 50 mg/kg/day, preferably 0.1 to 5 mg/kg/day.

Other embodiments are within the following claims.

Claims

1. A compound of the formula:



wherein

each A_1 and A_2, independently, is H C_{1-12} alkyl, C_{7-10} phenylalkyl, R_1CO (where R_1 is C_{1-20} alkyl, C_{3-20} alkenyl, C_{3-20} alkenyl, phenyl, naphytyl, or C_{7-10} phenylalkyl), or R_2OCO (where R is C_{1-10} alkyl or C_{7-10} phenylalkyl), provided that when one of A_1 or A_2 is R_1CO or R_2OCO, the other must by H;

each X_1 and X_2, independently, is H, F, Cl, Br, OH, CH_3, or CF_3, provided that at least one of X_1 and X_2 must be H;

A_3 is Phe or Tyr; and

A_4 is OH, NH_2, or NH-R_3 (wherein R_3 is a saturated aliphatic C_{1-8} alkyl):

or a pharmaceutically acceptable salt thereof.

2. The compound of claim 1, wherein

each A_1 and A_2, independently, is H of a saturated aliphatic C_{1-3} alkyl:

each X_1 and X_2, independently, is H, F, Cl, or OH, provided that at least one of X_1 and X_2 must by H; and

R_3 is a saturated aliphatic C_{1-3} alkyl;

or a pharmaceutically acceptable salt thereof.

3. The compound of claim 2, wherein said compound has the formula:

D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-βNal-NH_2,

or a pharmaceutically acceptable salt thereof.

4. The compound of claim 2 wherein said compound has the formula:

D-Phe-Cys-Tyr-D-Trp-Lys-Thr-Cys-βNal-NH_2,

or a pharmaceutically acceptable salt thereof.

5. A compound of the formula:

D-βNal-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH_2

or

D-βNal-Cys-Tyr-D-Trp-Lys-Thr-Cys-Thr-NH_2,

or a pharmaceutically acceptable salt thereof.

6. A therapeutic composition capable of inhibiting the release of GH; epidermal growth factor; insulin; glucagon; prolactin; exocrine secretions from the pancreas, stomach or intestines; the tachykining and substance P, said composition comprising a therapeutically effective amount of the compound of claim 1 or claim 5, together with a pharmaceutically acceptable carrier substance.

7. The therapeutic composition of claim 6, wherein said composition is capable of inhibiting the release of GH.

8. The therapeutic composition of claim 6, wherein said composition is in the form of a liquid,

pill, tablet, or capsule for oral administration to a human patient in need of said composition.

9. The therapeutic composition of claim 6, said composition being in the form of a cream, gel, lotion, spray, or ointment for application to the skin of a human patient in need of said composition.

10. The therapeutic composition of claim 6, said composition being in the form of a liquid capable of being administered nasally as drops or spray to a human patient in need of said composition.

11. The therapeutic composition of claim 6, said composition being in the form of a liquid for intravenous, subcutaneous, parenteral, or intraperitoneal administration to a human patient in need of said composition.

12. The therapeutic composition of claim 6, said composition being in the form of a biodegradable sustained-release composition for intramuscular administration to a human patient in need of said composition.

13. The therapeutic composition of claim 6, wherein said composition includes a lipophilic salt and is suitable for administration in the form of an oil emulsion or dispersion to a human patient in need of said composition.

14. A method of treating a mammal in need of reduction of GH; epidermal growth factor; insulin; glucagon; prolactin; exocrine secretions from the pancreas, stomach or intestines; the tachykining and

substance P, said method comprising administering to said mammal a therapeutically effective amount of the compound of claim 1 or claim 5.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US90/07074

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5):C07K 7/26; A61K 37/02
U.S. CL.: 530/311, 328, 317; 514/16

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	530/311, 328, 317; 514/16

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4,328,135 (SARANTAKIS), 04 May 1982, see the entire document.	1 & 6-14
A	US, A, 4,435,385 (BAUER et al), 06 March 1984, see the entire document.	1 & 6-14
A	US, A, 4,485,101 (COY et al), 27 November 1984, see the entire document.	1 & 6-14
Y	US, A, 4,853,371 (COY et al), 01 August 1989, see col. 1, lines 25-49; col. 2, lines 5-37.	1 & 6-14
Y	Proceedings 9th Annual Peptide Symposium Abstract, issued July 1985, Cai et al., "Synthesis and evaluation of activities of octapeptide analogs of Somatostatin", pp. 627-630, particularly page 628.	1,3 & 6-14

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
14 March 1991	29 APR 1991
International Searching Authority	Signature of Authorized Officer
ISA/US	T.D. Wessendorf

ebw

Form PCT/ISA/210 (second sheet) (rev. 11-87)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter [2] not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [3], specifically:

3. ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

See attachment

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

1 and 6-14 (First listed specie) Telephone Practice.

4 ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Attachment to PCT/ISA/210

This application is directed to a generic inventions containing multiple species.

Applicants are required to elect disclosed specie from the claimed genus. For example, a single definition for each of the given variables like A_1 definition H; A_2=H, A_3= PHe, A_4=OH;X, =H; X_2=F; etc. or species from claims 3-5.

Each of the species comprised in the genus are distinct since they are physically or structurally dissimilar. One specie in the claimed genus containing specific definitions for each variables would not suggest the other species containing different definitions for the same given variable(s).

In conformance with PCT Rule 13.1, the composition comprising the peptide (specie) and method of using said peptide i.e. claims 6 -14 would be examined with the elected (peptide) specie.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to T. Wessendorf whose telephone number is (703) 308-3697.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 309-0196.